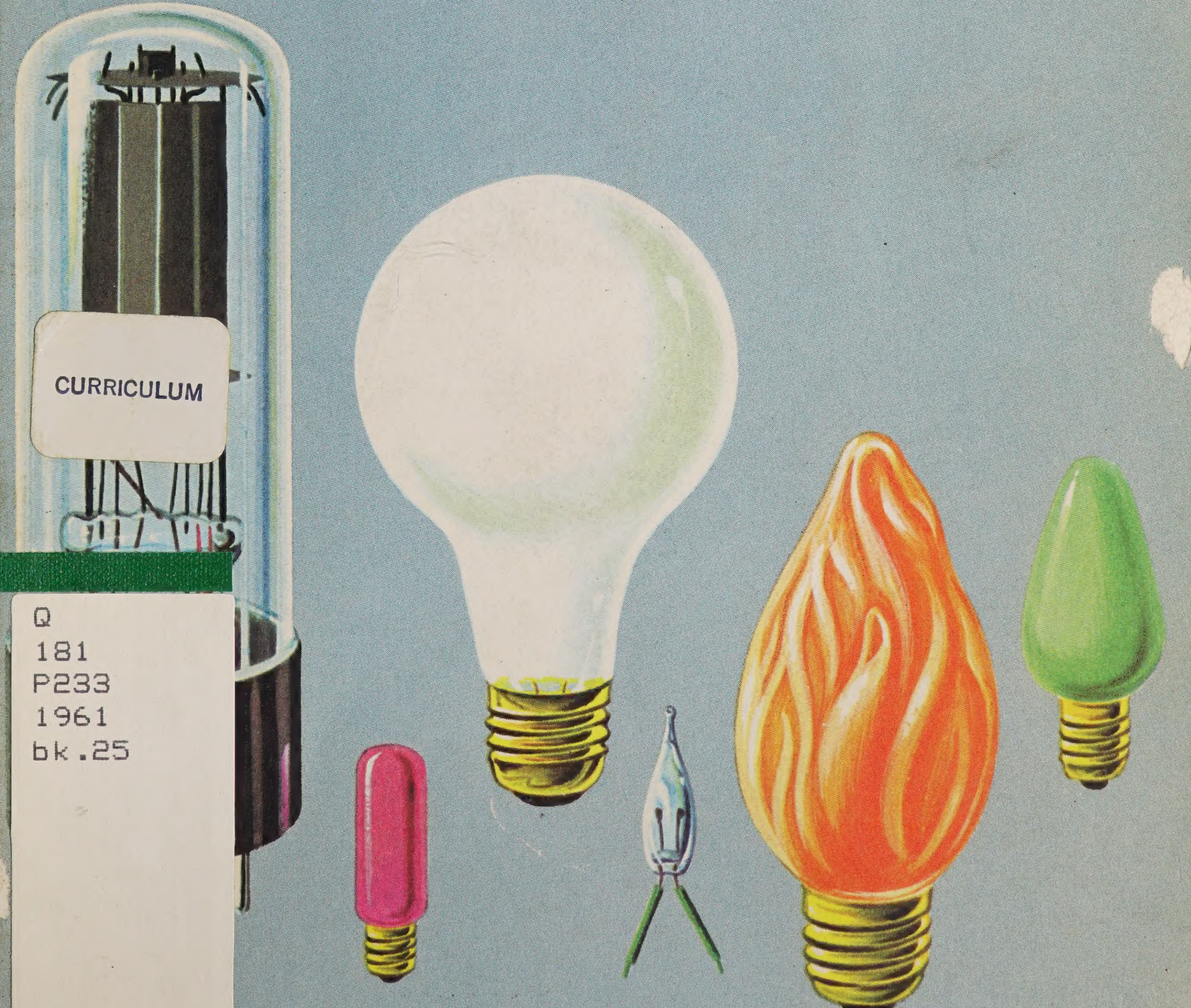
UNIVERSITY OF ALBERTA
0 0003 23198 81

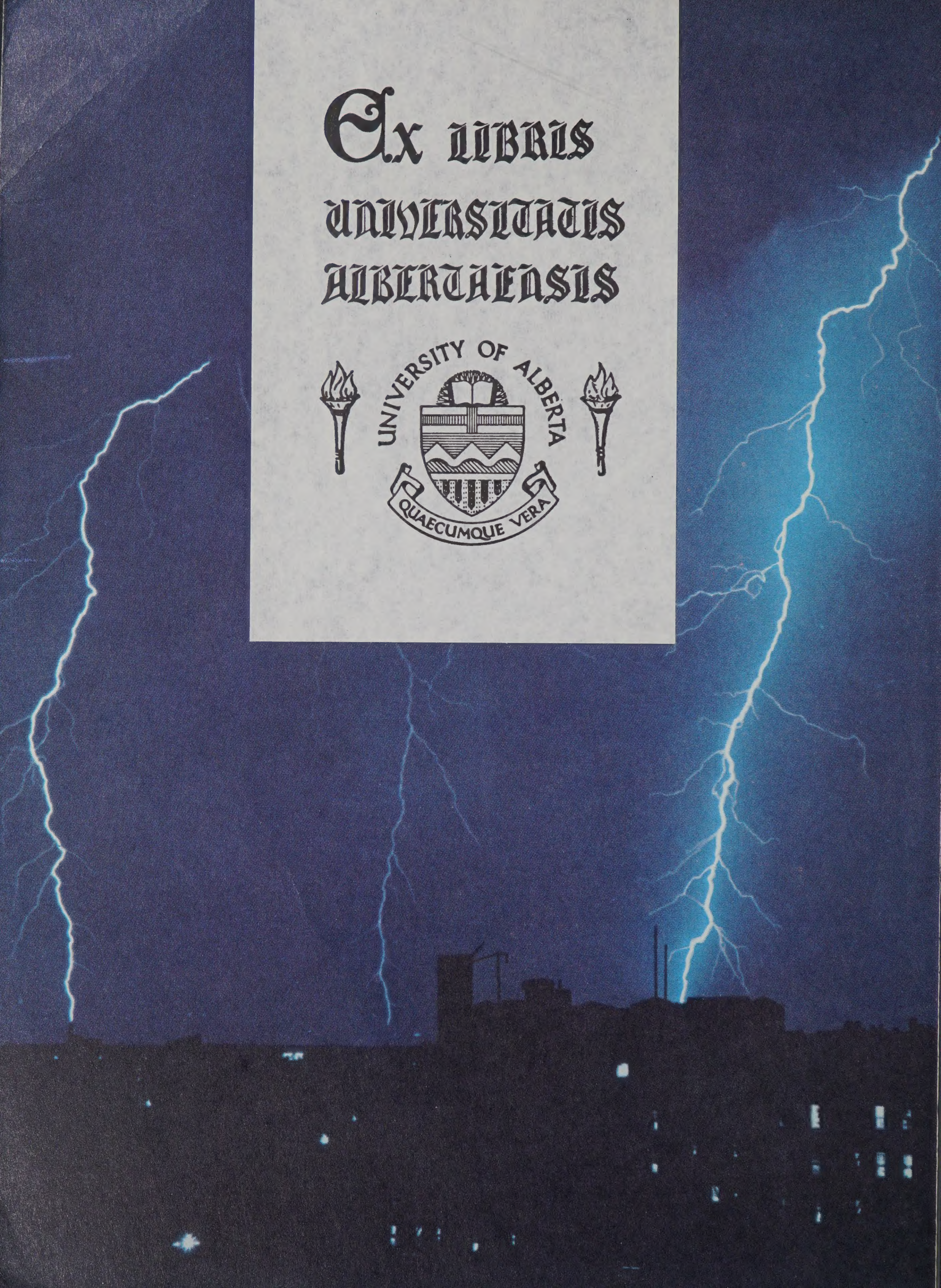
Electricity



CURRICULUM

Q
181
P233
1961
bk.25

CURR HIST



Ex libris
Universitatis
Albertaensis

UNIVERSITY OF ALBERTA
QUAECUMQUE VERA

THE BASIC SCIENCE EDUCATION SERIES

A BASIC SCIENCE
UNITEXT
Intermediate

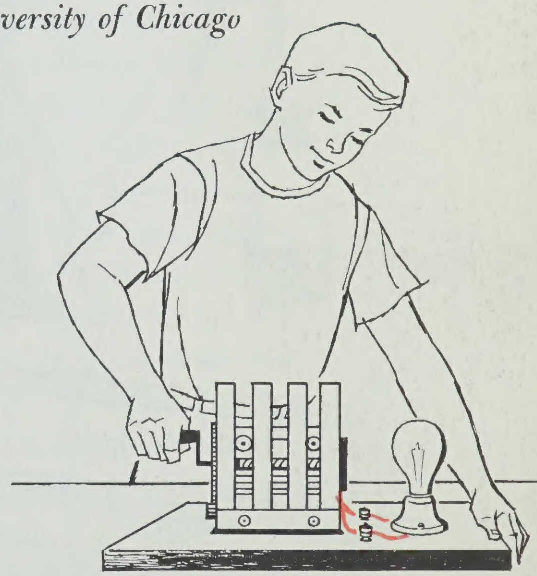
Electricity

by BERTHA MORRIS PARKER

LABORATORY SCHOOLS, UNIVERSITY OF CHICAGO

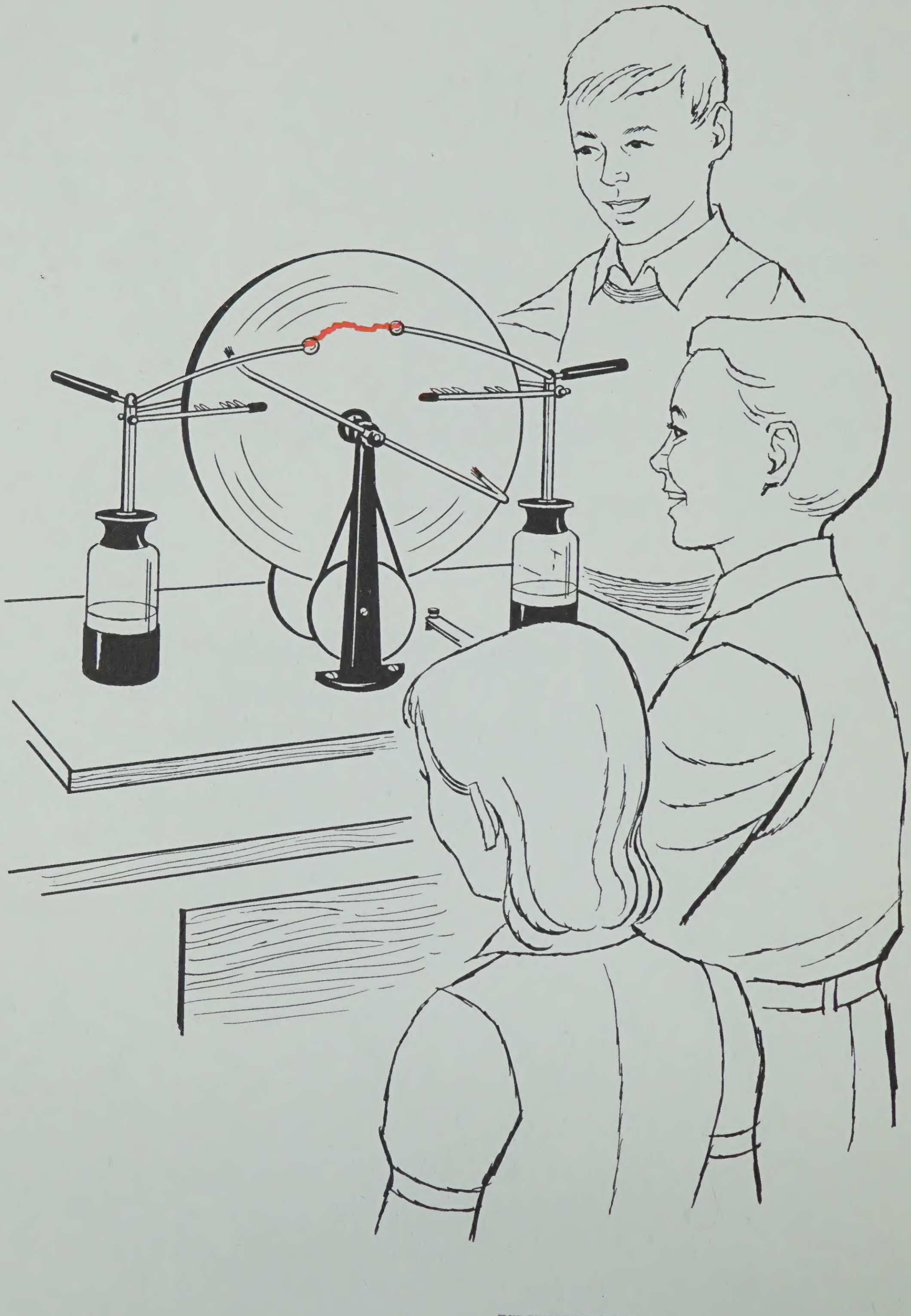
Checked for Scientific Accuracy by
CLIFFORD HOLLEY
Assistant Professor of Natural Sciences, University of Chicago

COVER AND ILLUSTRATIONS BY JAMES TEASON



HARPER & ROW, PUBLISHERS
EVANSTON, ILLINOIS • ELMSFORD, NEW YORK • PLEASANTON, CALIFORNIA
1963

COPYRIGHT © 1959, 1944 HARPER & ROW, PUBLISHERS, INCORPORATED, 6886



UNIVERSITY
OF ALBERTA LIBRARY

Electricity

Little Lightning

LIGHTNING is a huge spark of electricity. The spark may jump from a cloud to the ground. It may jump from one cloud to another. In the picture on the inside front cover it is jumping from a cloud to the ground.

The machine in the picture on page 2 is an electric machine. One of the boys is turning the handle. As he turns it, sparks of electricity jump from one knob of the machine to the other. These sparks are like small flashes of lightning. We can call them "little lightning."

When you see a real flash of lightning, you expect to hear thunder soon. Lightning causes thunder. Little lightning makes a noise, too. The children in the picture hear a crackle whenever a spark jumps across the gap between the knobs.

You do not have to have an electric machine to get little lightning. On some cold, clear day shuffle your feet across a thick rug. Then touch a radiator or something else made of metal. A tiny spark will jump from your finger to the metal. You may not see it, but you will feel it. You will get a little shock. You will hear a tiny crackle, too. If you do this experiment in the dark, you will also see the spark.

Many people used to light their houses with gas. In those days it was a common trick for a person to shuffle across a thick rug and then light the gas with a spark of electricity.

534168

You may have heard a crackling sound when you combed your hair on a cold morning. You may have seen sparks when you stroked a cat in the dark. You may have got a shock on a cold day when you touched a car that had just stopped. Little lightning again!

To get little lightning, you must have a *charge of electricity*. An easy way to get a charge is to rub two different materials together. When you shuffle across a rug, you are rubbing your shoes against the rug. When you stroke a cat, you are rubbing your hand against the cat's fur. When you comb your hair, you are rubbing your hair and the comb together. The tires of a car rub against the pavement.

Whenever two things rub together, there is *friction*. Since charges like those you have been told about come from rubbing, they are often called *frictional electricity*. Another name for them is *static electricity*.

"Static" means "standing still." Charges of electricity often do stand still. But when you see sparks of static, the charges are not standing still. They are going somewhere very fast.

The girl in the picture on page 4 is experimenting with static electricity. She has rubbed her comb with a piece of wool. She is not getting sparks from it. But she is picking up pieces of tissue paper. Anything that has a charge of electricity will pick up small bits of such things as paper and cork.

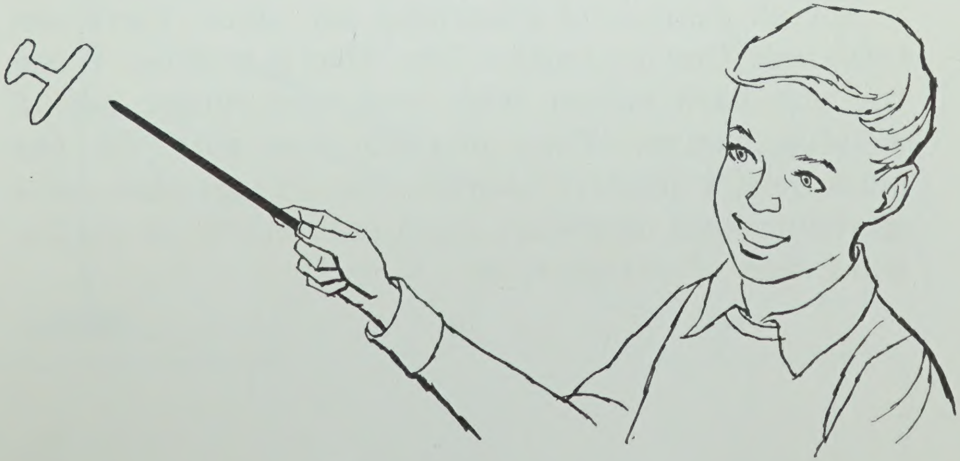
After she has held up the comb for a moment or two, the bits of paper will begin jumping away from it. As they stick to the comb, they get a charge of electricity from the comb. Then the comb pushes them away.

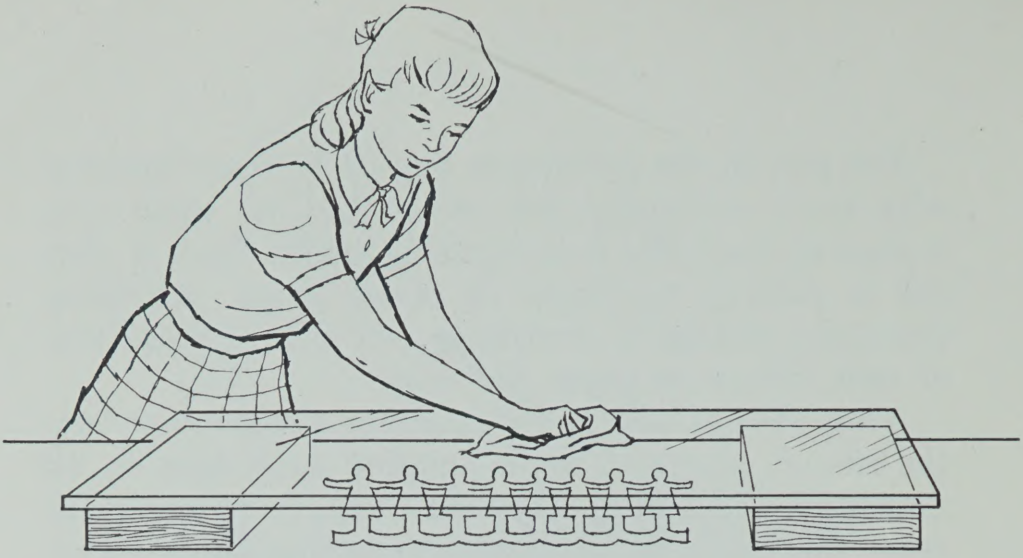
At first, you see, the comb *attracts* the bits of paper. "Attract" means "pull." Then it *repels* them. "Repel" means "push."

The boy in the picture at the bottom of the page is playing with a static electricity toy. The little airplane is made of aluminum foil. Aluminum foil is very light. The rod he has in his hand is made of hard rubber.

First he rubbed the rod with fur. Then he held it up in the air and held the little airplane near it. He let go of the airplane. The rod attracted it. But in a moment the airplane jumped away from the rod. It was charged, too. The rod is now repelling the airplane. The boy can make it fly wherever he wants it to.

In the picture on the next page the girl is making some paper dolls dance. She is rubbing a flat piece of glass with a silk cloth. Rubbing the glass gives it





a charge of electricity. It makes the dolls jump up to it. They become charged and jump down. After they are back on the table, they lose their charge. Then the glass pulls them back up again. They keep on jumping up and down.

The girl in the picture on page 7 is experimenting with a little ball of pith. Pith is the soft material that comes from the inside of the stems of some plants. The ball of pith is tied to a silk thread. The other end of the thread is tied to a small iron stand.

The girl has a hard rubber rod. She has just rubbed it with a piece of woolen cloth. It is attracting the pith ball. If she lets the pith ball touch the rod, it will get a charge. Then the rod will repel it. If the ball happens to touch the iron stand, it will lose its charge and jump back to the rod.

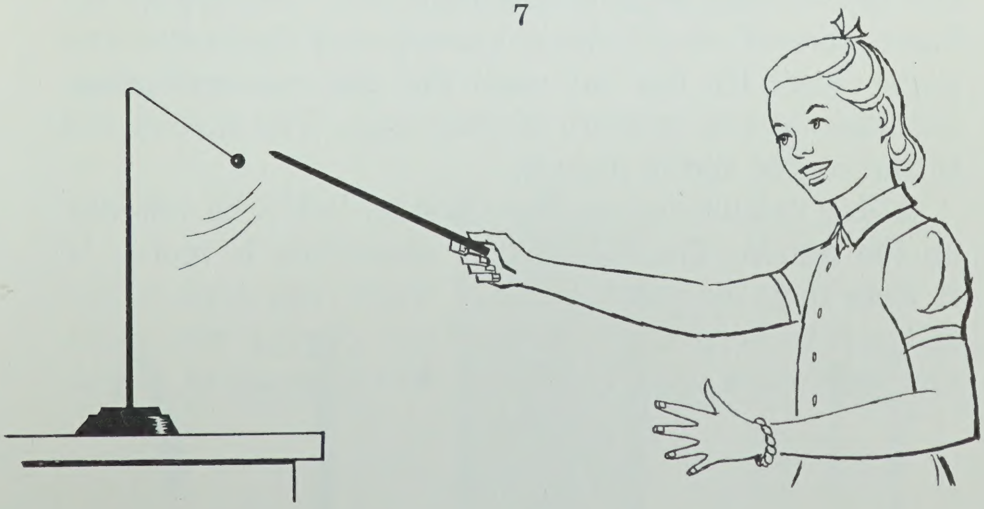
Not all charges of electricity are alike. There are two kinds. One is *negative*. The other is *positive*. When you rub hard rubber with wool, the rubber gets a negative charge. When you rub glass with silk, the glass gets a positive charge. Two things that have the same kind of charge repel each other, no matter what kind of charge it is.

When two things have different kinds of charges, they attract each other. They act just as the comb acts with the bits of paper that are not charged at all.

Experiments with static electricity work best when the air is dry. If the air is moist, the charges of electricity will escape into it. The air is more likely to be dry on a cold day than on a hot one. It is, then, better to try experiments with static electricity on a clear, cold day.

Static electricity may be a nuisance. On a cold day the paper you are writing on may stick to your arm. Your hair may stand on end because all the hairs have the same kind of charge and are repelling one another. You may get unpleasant little shocks whenever you touch things made of metal.

But sparks of static can be more than a nuisance. Of course, lightning can do a great deal of harm. Little sparks can do a great deal of harm, too. A rubber hose may get charged when gasoline runs through it. A spark may jump from it and set the gasoline on fire. In flour mills a tiny spark may make the dust in the air explode. People who work with anything that will burn very easily must always be on their guard against little lightning.



Cells

A spark of electricity will not make your doorbell ring. It will not light your flashlight. It will not make your electric train run. In fact, static electricity is not of much use. For the electrical things we use we need *electric currents.* An electric current is a flow of electricity.

One way of getting currents of electricity is to use cells. There are several different kinds.

The dry cell is one of the commonest kinds. The middle diagram on the next page shows a dry cell cut down through the center. The boy in the picture at the top of this page is taking a dry cell apart. He has taken off the cardboard cover and the metal and paper caps. He has cut open the zinc can and taken out some of the mixture of chemicals. The carbon rod in the center shows plainly.

A dry cell is dry on the outside, but it is not dry on the inside. The mixture of chemicals is moist. If it were dry, the cell would not work. The caps on the cell are to keep the mixture from drying out. Some dry cells have caps of sealing wax instead of metal.

At the top of the carbon rod there is a little post to which wires can be fastened. This is a *binding post.* There is another binding post fastened to the top of the zinc can.

The zinc post is often marked with a minus sign (—). This means "negative." The carbon post is often marked with a plus sign (+). This means "positive."

A current does not flow from a dry cell all the time. It does not flow unless it has a path from one binding post to the other.

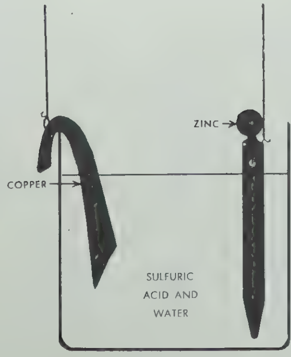
In every kind of cell there is some chemical. In every one there is zinc or something that will take its place. And in every one there is carbon or something that will act like carbon.

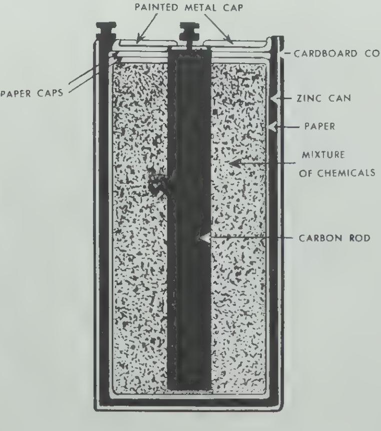
The first diagram on this page shows one kind of wet cell. It has copper in it instead of carbon. The chemical is an acid.

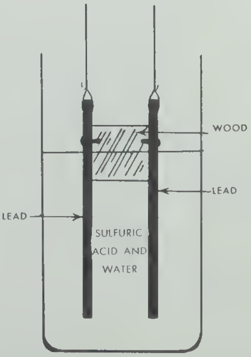
We do not often use cells like this. It is easy to see one reason why. They are hard to carry about.

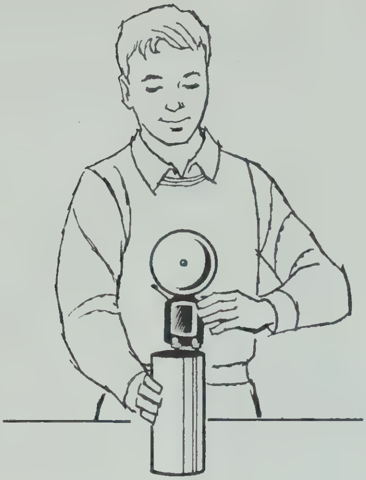
You are sure to have heard the word *battery.* A battery is made up of two or more cells joined together.

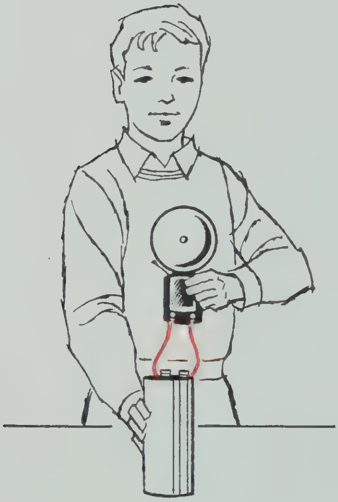
Every car has a *storage battery* in it. A storage battery is made up of storage cells. The last diagram on this page shows a little homemade storage cell. It will not give an electric current unless a current is first sent through it for some time. Then it will give a current just as any cell does.

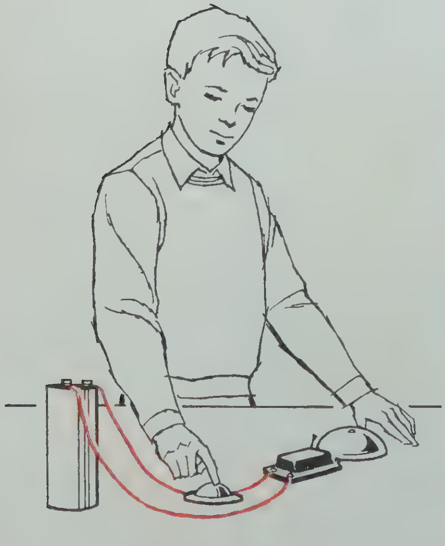












Ringing Bells

An electric bell will not ring unless a current of electricity flows through it. In each of the pictures on this page the boy is sending a current through his bell and making it ring.

An electric bell has two binding posts. In the top picture the boy is holding the two binding posts of the bell against the two binding posts of the cell. The current flows through the bell from one binding post of the cell to the other.

In the second picture the boy has made a longer path for the current. He has used two pieces of wire to connect the two binding posts of the bell with the two binding posts of the cell. The current of electricity flows through one wire, then through the bell, and then back to the cell through the other wire.

To make the bell stop ringing, the boy does not have to take both wires off the cell. If he takes one end of either wire away from the binding post it is fastened to, the bell will stop ringing. If there is even a little gap in its path, the current will not flow at all.

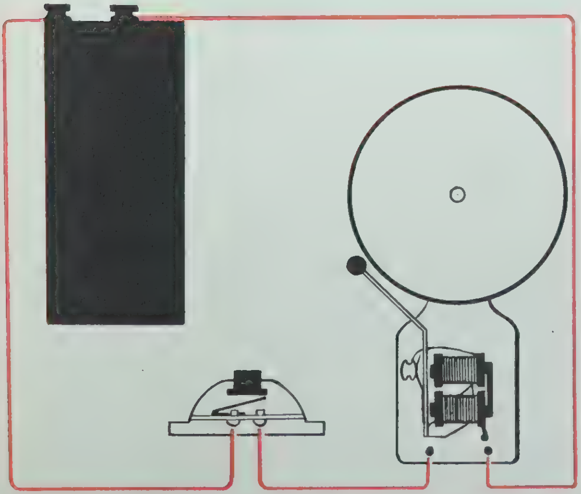
In the third picture the boy is using a bell, a cell, and a push button. He is using three pieces of wire.

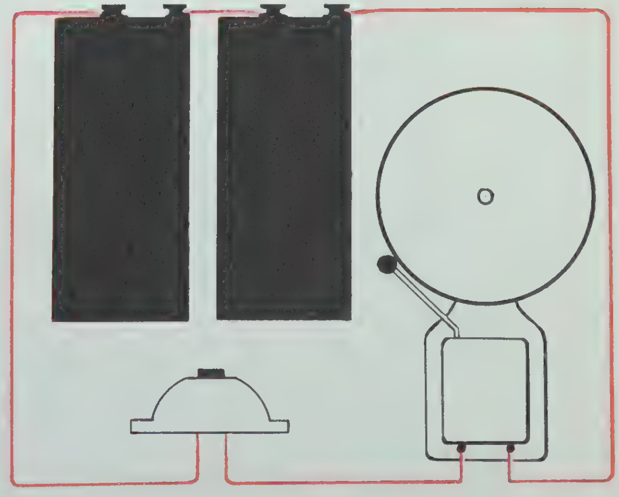
The first diagram on this page will help you see how the bell, cell, and push button are connected. The diagram shows the bell with its cover off. It shows the inside of the push button, too. There is a bent piece of brass inside the push button. The wires are fastened to two screws. Unless the button is pushed down, the current cannot get across the gap between the screws. But pushing down the button closes the gap. It presses down the piece of brass so that it makes a bridge between the two screws. The minute the pushing stops, the piece of brass springs up again.

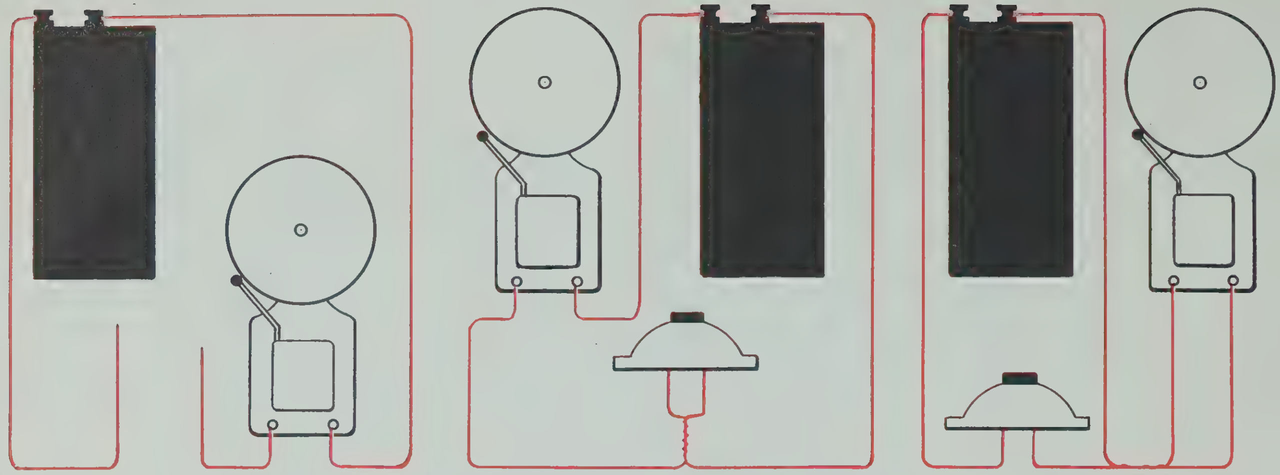
The path a current of electricity follows is called a *circuit*. When there is no gap in the path, we say that there is a *complete circuit*. When there is a gap somewhere in the path, we say that there is a *break in the circuit*. In the first diagram on page 12 it is easy to see the break in the circuit.

Now that you know how a push button works, you can see that there is a break in each of the circuits shown on this page. It is at the push button. But pushing the button makes the circuit complete.

If one cell does not make a bell ring loudly enough, more cells can be used. But there is a right way and a wrong way to connect them. The second diagram on this page shows you the right way. A positive post must be connected to a negative post.







Suppose you did not have any wire. Could you use string to connect a cell, a bell, and a push button? No, you could not. Electricity flows easily through some materials. It does not flow easily through others. The materials it flows through easily are called *good conductors of electricity*. The materials it does not flow through easily are called *poor conductors*. String is never made of a good conductor. It would not, therefore, make a good path for an electric current.

Wires are made of metal. All metals are good conductors, but some are better than others. Silver is the very best, but it costs too much to be used in wires. Copper is next best, and it is used a great deal.

Much of the wire we use is wrapped with a poor conductor. The wrapping is like the fences at the sides of a racetrack. The fences keep the horses on the track. The wrapping keeps the current on its path.

Wire that is wrapped with a poor conductor is called *insulated wire*. Cotton, silk, rubber, and enamel are often used to insulate wire. When we make connections with insulated wire, we have to take the wrapping off the ends of the wire.

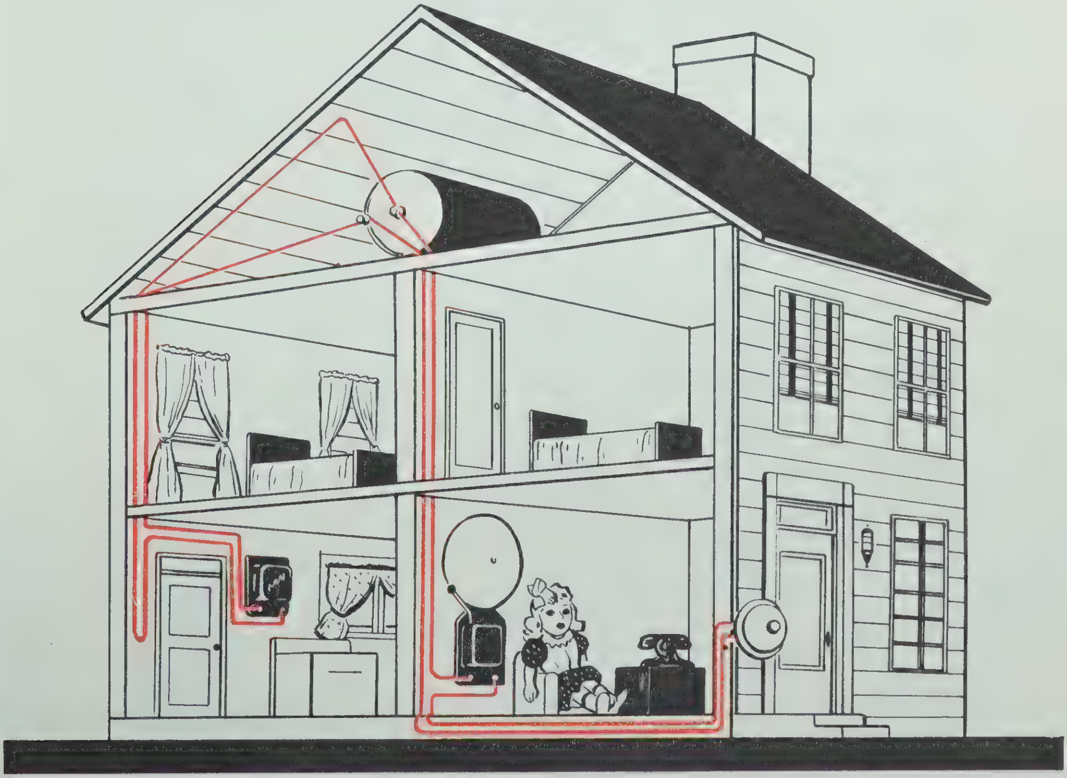
A current will always follow the easiest path it can. Suppose the wires of a circuit were not insulated. If the wires touched each other, they would let the current follow a shorter and easier path than the one it is supposed to follow. There would be a *short circuit.*

The second and third diagrams on page 12 show two short circuits. The wire in these circuits is bare wire. Where the wires are twisted together, the current would flow from one to the other.

In the middle diagram the current would take a short cut back to the cell without going through the push button. The bell would ring all the time. But in the third diagram the bell would not ring at all. When the button was pushed, the current would take a short cut back to the cell without going through the bell.

There is a push button at each door of the dollhouse in the picture on this page. When the one at the front door is pushed, the bell rings. When the one at the back door is pushed, the buzzer buzzes. A buzzer is very much like a bell, but it buzzes instead of ringing.

Notice that there is only one cell. There are two circuits, but the same cell is in both of them.



Your Flashlight

Flashlights are very useful. They help us find our way about in the dark. They help us hunt for things that have rolled under the furniture or into dark corners. Probably you have a flashlight of your own.

The two diagrams on the next page will help you understand how your flashlight works. The first one shows a circuit with a flashlight bulb, a switch, and two cells in it. The second diagram shows the inside of a flashlight. Here, too, is a circuit with two cells, a flashlight bulb, and a switch in it.

A flashlight bulb is a tiny electric lamp. It lights up whenever a large enough current flows through it.

A switch makes and breaks a circuit, just as a push button does. The switch in the first diagram has a copper arm that can be moved up and down. This arm acts like a bridge. When it is down, we say that the switch is closed. Electricity can travel through it. When the arm is up, we say that the switch is open. No current can travel through it, for the base of the switch is made of a very poor conductor of electricity.

It is easy to trace the path of the current in the first diagram. When the switch is closed, the current flows through wires from the cells to the little lamp and the switch and then back to the cells.

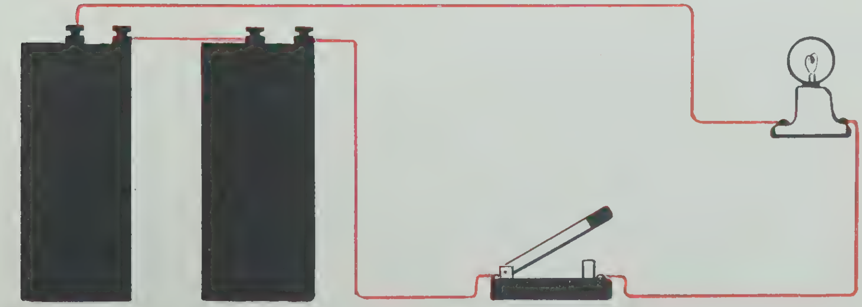
It is not so easy to trace the path of the current in the flashlight. The bulb is at the center of a little metal bowl. The switch is at the side of the case. When the switch is closed, a piece of metal touches the metal bowl. The cells fill up most of the case. A spring keeps them pushed up so that the top one touches the bottom of the bulb. Notice that there are not any wires to connect the switch and cells and flashlight bulb.

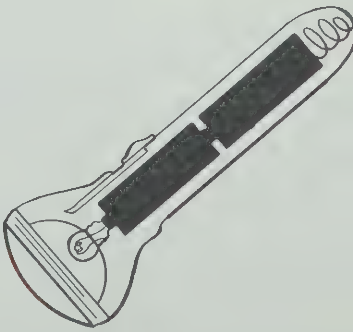
Now let us trace the path of the current when the switch is closed. We shall start with the bottom cell. The top of the carbon rod of this cell touches the bottom of the zinc can of the next cell. No wire, you see, is needed to join the two cells.

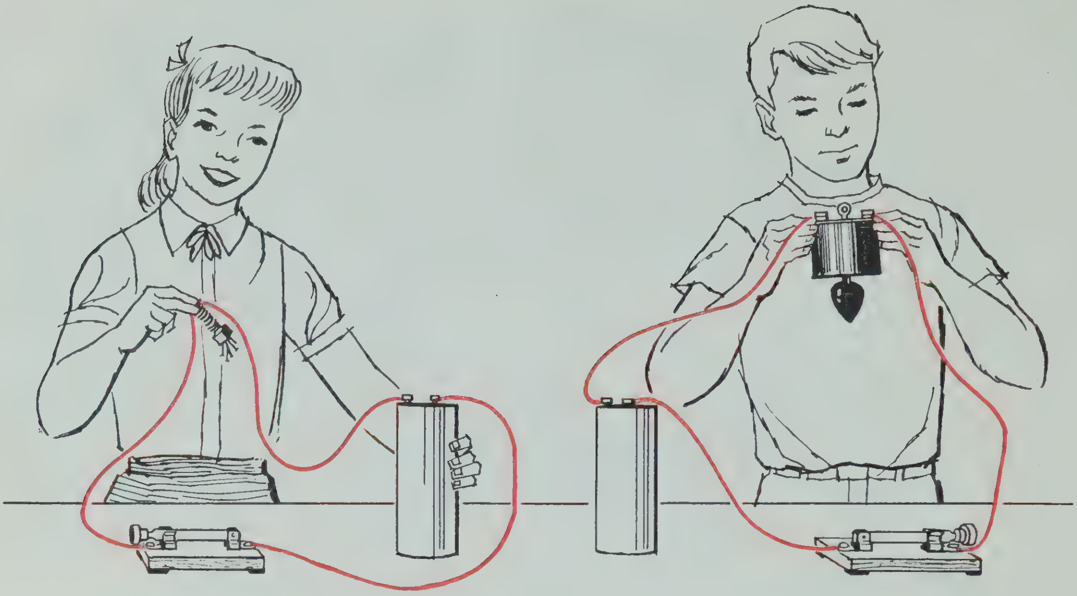
The carbon rod of the next cell touches the bottom of the bulb. The current flows from the cells to the bulb. From the bulb it flows through the metal bowl and the switch to the metal case. It travels to the spring and then through the spring to the bottom cell. Do you see that there is a complete circuit?

Not all flashlights are just alike. But if you can trace the path of the current in the one in the diagram, it will be easy for you to see how others work.

The circuits on this page are much like the bell circuits you read about. Each one has something to furnish a current of electricity, something to use the current, and some way to make and break the circuit.







Electric Magnets

Probably you have played with small magnets. If you have, you know that a magnet will pick up things made of iron or steel. But did you know that some magnets will pick things up and then put them down again?

The magnets that pick things up and put them down again are electric magnets. *Electromagnets* is another name for them.

An electric magnet is made of a piece of iron with many turns of wire wrapped around it. Unless a current of electricity is flowing through its wire, an electric magnet will not pick up anything.

The boy and girl in the picture at the top of the page are playing with small electric magnets. The girl's magnet is homemade. It is an iron bolt with several yards of insulated copper wire wrapped around it. The boy's magnet was made in a factory. It has an iron center, or core, too, with many yards of wire wrapped around it. But you cannot see the wire in the picture. An iron case hides it.

Each magnet is in a circuit with a dry cell and a switch. Each one is holding a small load of iron. Notice that the switches are closed. As soon as they are opened, the magnets will drop their loads.

Electric magnets are fun to play with. They are also very useful.

The picture on this page shows a big electric magnet lifting a load of iron. The magnet will carry its load to some other place and then drop it.

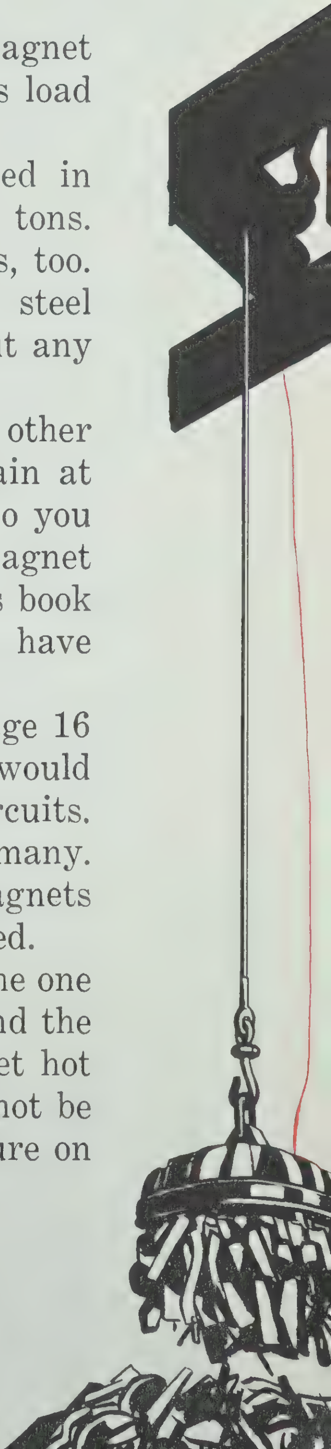
Many electric magnets like this one are used in factories. Some of them can lift loads of several tons.

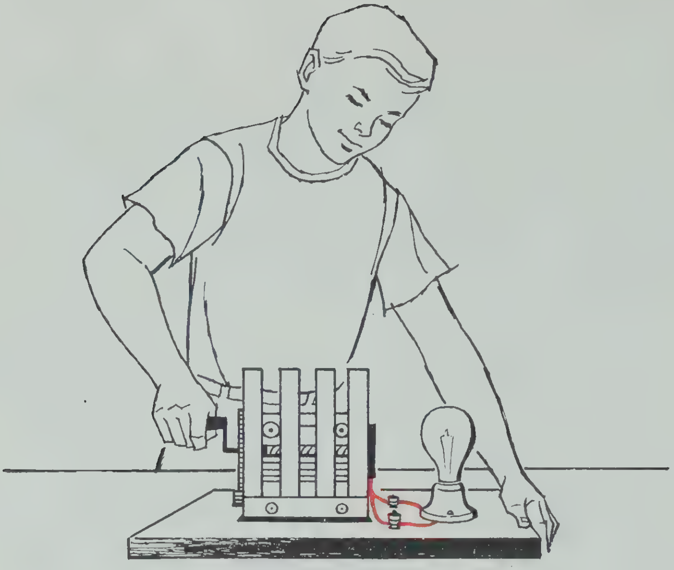
Smaller electric magnets are used in factories, too. In needle factories they gather up the bits of steel that fall on the floor. In flour mills they take out any bits of iron that are in the grain.

Besides, electric magnets are a part of many other things that are worked by electricity. Look again at the bell in the left-hand diagram on page 11. Do you see the electric magnet in it? It is the electric magnet that pulls the clapper over against the bell. This book will tell you about several other things that have electric magnets in them.

Suppose the boy and girl in the picture on page 16 wanted to make their magnets stronger. All they would have to do would be to put more dry cells in the circuits. But they would have to be careful not to use too many. If they used too many, the wires of their magnets would get hot. The magnets could not be handled.

You may wonder why, in a little magnet like the one the girl is using, so much wire is wrapped around the bolt. If only a little wire were used, it would get hot much more quickly. Besides, the magnet would not be so strong. A big magnet like the one in the picture on this page has many pounds of wire in it.





Electricity for Our Streets and Buildings

It would take hundreds of cells to work the big magnet in the picture on page 17. Besides, the cells would soon wear out. No one would ever use big electric magnets if cells were the only way of getting currents of electricity. The current for big electric magnets comes from *generators.*

The current that comes into our houses and other buildings also comes from generators. So does the current for the lights and stop signs on our streets. The generators are in power plants.

The boy in the picture on this page is using a small generator. It is not, you can see, at all like a cell. It is made of four U-shaped magnets and a coil of wire. The ends of a magnet are called *poles.* The coil of wire in the generator is between the poles of the magnets.

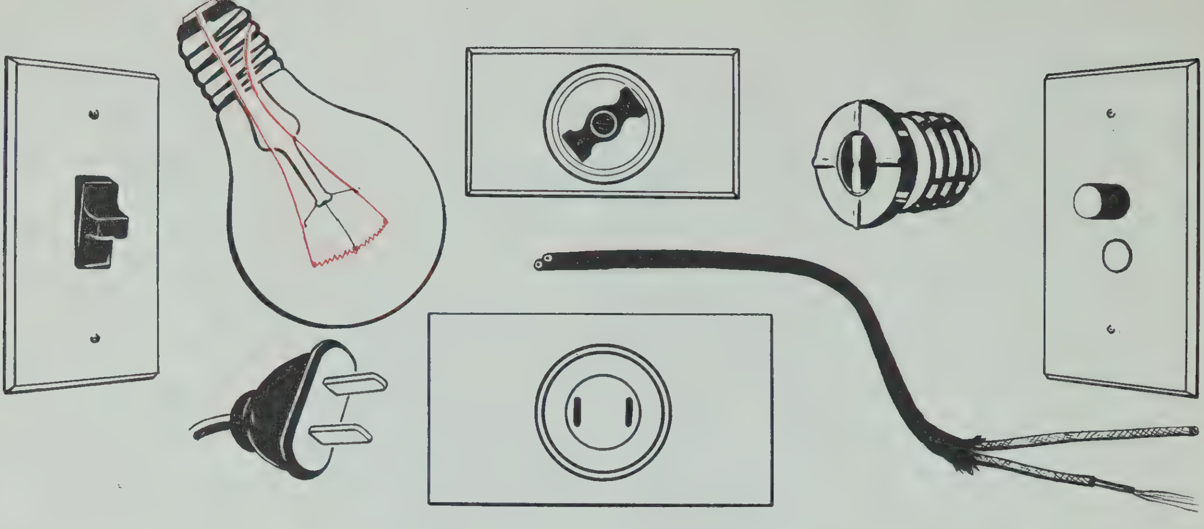
Notice that the boy is turning a handle. Turning the handle turns the coil of wire around and around between the poles of the magnets. If the handle is turned fast enough, the generator will give a strong enough current to light the electric lamp.

The generators in power plants are much, much bigger than the one the boy is using. But they are made of magnets and coils of wire just as little generators are. The magnets in them are big electric magnets.

In big generators the coils of wire are sometimes turned. Sometimes the magnets are turned instead. Either the magnets or the coils must be turned, or no current will come from the generators. But they are not turned by people. Steam turbines drive many generators. Water wheels drive many others.

The picture on this page shows a big generator. Generators like this are driven by water wheels. You would find many generators of this kind in power plants at falls and big dams.

The current from cells always flows in the same direction. It is a *direct current*. The current from a generator may be a direct current. It may be an *alternating current* instead. An alternating current flows back and forth. When you buy anything electrical for your house, you need to know what kind of current you use.



Can you tell what all the things in the pictures at the top of this page are? One is an electric light bulb. You can find it easily. Three are wall switches. One switch is at the far right. Another is at the far left. The third is in the middle at the top.

One picture shows a piece of an electric cord. An electric cord always has two wires in it. These wires are well insulated.

Below the wire is a wall outlet. Two wires come up through the wall to an outlet like this. Below the light bulb there is a plug for the end of a cord. Pushing a plug like this into a wall outlet joins the two wires in the cord to the two wires of the outlet.

Above the middle of the piece of cord there is a fuse. Fuses help protect us from fire. Every electric circuit in our houses has a fuse somewhere in it. Usually the fuses are in the basement.

In a fuse there is a small strip of metal that melts easily. Suppose there is a short circuit in your house. The short circuit may let a stronger current than usual flow through the wires. The wires may get hot. The strip of metal in the fuse then gets hot, too. It melts and breaks the circuit. It keeps the wires from getting hot enough to set the house on fire.

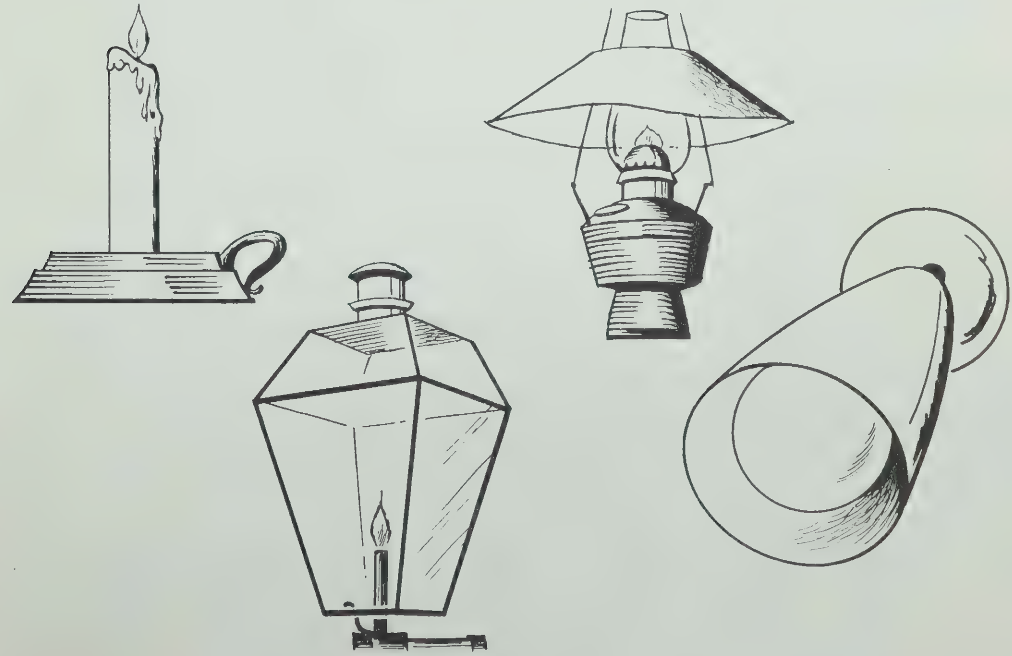
Electric Lights

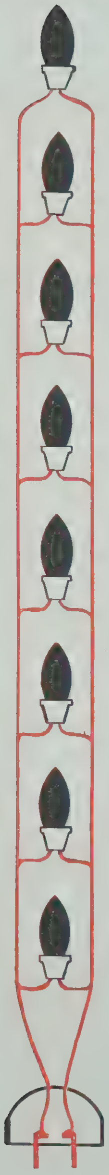
Suppose you had to go back to living the way people lived a hundred years ago. One of the things you would miss most would be electric lights. Electric lights make our streets and buildings almost as light at night as they are in the daytime. They turn hours of darkness into hours for working and playing.

A hundred years ago people had ways of lighting their streets and buildings. They had candles and oil lamps and gas lamps. But it would be hard for us to go back to these ways of lighting. Using electric lamps is much easier.

Using electric lamps is safer, too. Candles and oil and gas must burn to give light. They burn with a flame and can easily set other things on fire. In an electric lamp nothing is burning.

There is a fine wire in an electric light bulb that gets very hot when a strong current of electricity flows through it. It gets so hot that it gives off light. The wire is made of the metal tungsten. The path of the current through a bulb is shown in red on page 20.





The air is pumped out of a bulb. There may be a *vacuum* left in it. A vacuum is an empty space. Or the bulb may be filled with argon or some similar gas. The tungsten wire would not last long if there were any air around it.

The diagrams on this page show two strands of Christmas tree lights. In the strand at the bottom of the page all the little lamps in the strand go off if one does. Suppose the tungsten wire in one lamp breaks. Then there is a break in the circuit. No current can flow through any of the lamps. When we connect lamps in this way, we say that we are connecting them *in series.*

In the strand at the side of the page one lamp can go off without making all the others do so. The current can still flow through all the others. These lamps are connected *in parallel.*

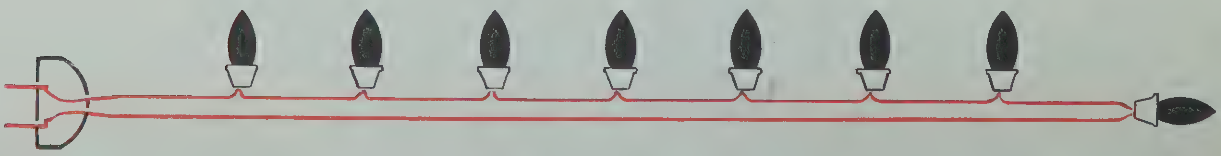
The ordinary lamps in our buildings are connected in parallel. The wires are hidden in the walls. Several lamps are in one circuit. Any of them can be turned off without making the others go out.

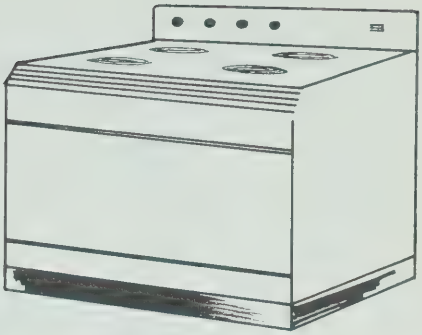
Some of the electric signs on our streets are made of light bulbs. Others are made of long tubes. Most of these tubes send out colored light.

There are no wires running through these tubes. Instead, they are filled with a gas. When the current flows through a tube, it lights up the gas.

Different gases give different colors. *Neon* is used most often. It gives a bright-red light.

In your house you may have some *fluorescent* electric lamps. These lamps are straight tubes. They have a coating inside that glows when a current of electricity is sent through them. Most of our electric lights may soon be lamps of this kind.





Heat without Fire

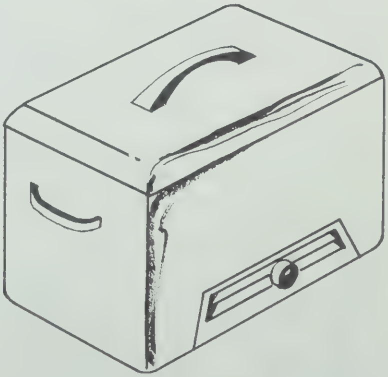
For thousands of years people have been using fire for cooking. Even the cave men knew how to cook over a fire. But cooking without fire is new. Cooking without fire means cooking with electricity.

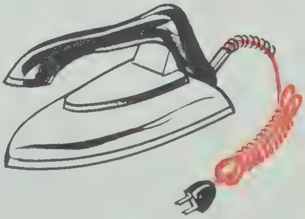
The top picture on this page shows an electric stove. An electric stove does not look like an electric light bulb, but it works very much the same way. In a stove there are wires that get hot, just as the wire in an electric light bulb does. They do not get so hot as the wire in a light bulb, but they get hot enough to give off a great deal of heat.

The other pictures on this page show more ways of using electricity to give heat. Can you find in the pictures the electric iron, the heating pad, the oven, the toaster, and the coffee-maker? All of these heating devices have wires in them that get very hot when a strong current of electricity runs through them. But in most of them the wires are hidden.

The diagram on the next page shows the wires in an electric iron. These wires are hidden in the iron.

Suppose you are going to use an electric iron. You push the plug on the end of the cord into a wall outlet.





The current flows through the wires of the iron. Soon the iron is hot. How much faster this is than the old-fashioned way of heating an iron! The old-fashioned way was to build a fire in a stove and heat the iron on top of the stove.

The pictures on page 23 show ways we use electricity to give us heat in our homes. We also use electricity a great deal in factories to furnish heat.

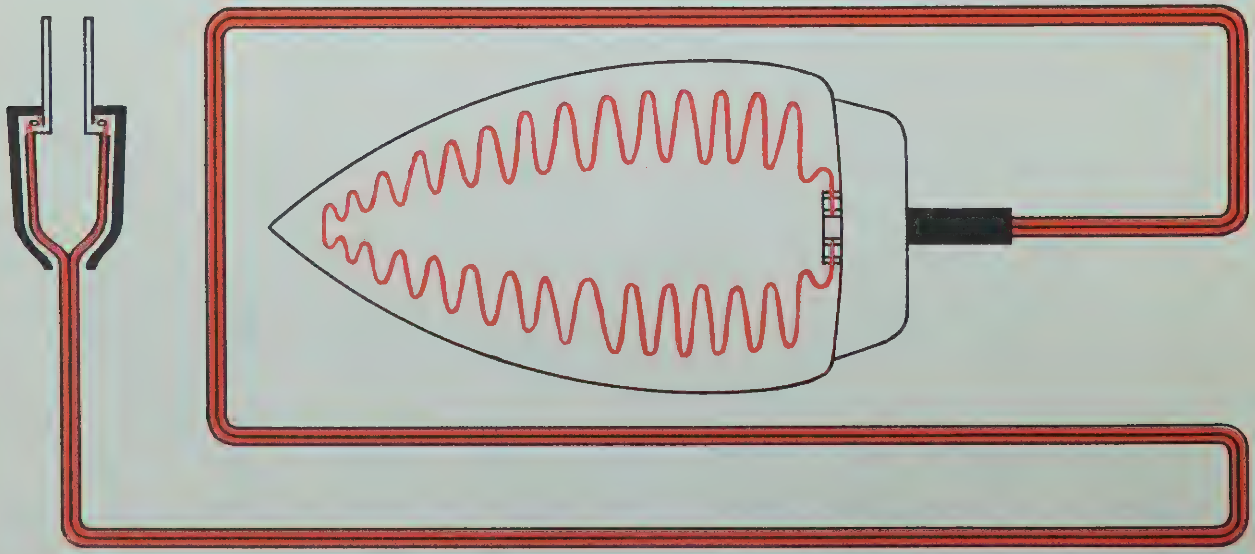
Perhaps you have heard of electric welding. In electric welding electricity is used to melt two pieces of metal together.

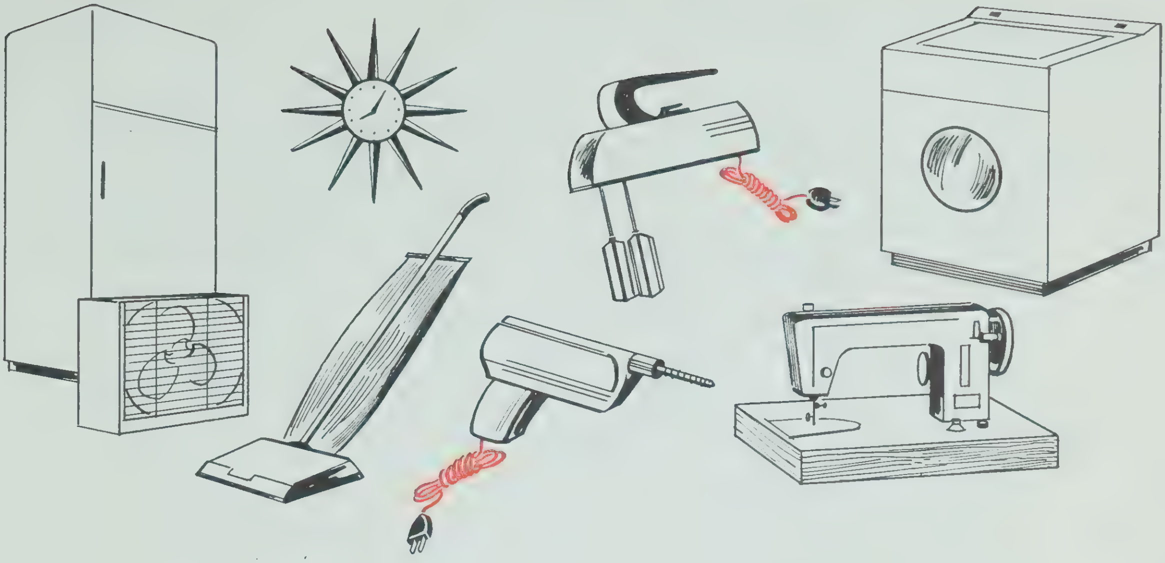
Many factories use electric furnaces. In an electric furnace the temperature may be 7,000° F. (7,000 degrees, Fahrenheit). You can get an idea of how hot 7,000° F. is when you know that water boils at 212° F.

Some electric furnaces are used to melt metals. Some are used to make steel. Some are used to make glass that will stand a very great deal of heat.

Artificial rubies and sapphires can be made with an electric furnace. Even tiny artificial diamonds can be made with the help of heat from electricity.

We could not afford to use electric stoves and toasters and furnaces if the current for them had to come from cells. Electricity was not used for heating until generators were invented.





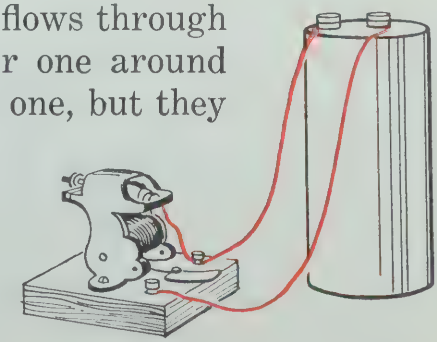
A Magic Servant

Pretend that you are in a magic house where you have a magic servant. You cannot see your servant, but he does many things for you. He fans you when you are hot and keeps your food cold for you. He washes your clothes and cleans your house and sews. He whips cream and mixes bread. He keeps time for you. He runs tools for you in your basement workshop. Wouldn't it be fun to have such a servant?

Really you do have. Your servant is electricity. It does all the kinds of work you were pretending the magic servant did.

Electricity does such kinds of work by making electric motors run. The electric motors run other machines. In your home you probably have many of the machines shown in the pictures at the top of the page. These all have electric motors in them.

The picture below shows a small electric motor. This little motor has two electric magnets in it. One magnet always stands still. When a current flows through the motor, this magnet chases the other one around and around. Not all motors are like this one, but they all have electromagnets in them.



Electric motors do a great deal of work for us outside our homes. They move the elevators and escalators that take us from floor to floor in tall buildings. They run electric trains. They help start automobile and airplane engines. At the movies they wind and unwind the films. Electric motors play a big part in air-conditioning systems. They drive great printing presses. They run thousands of kinds of machines in mills and factories.

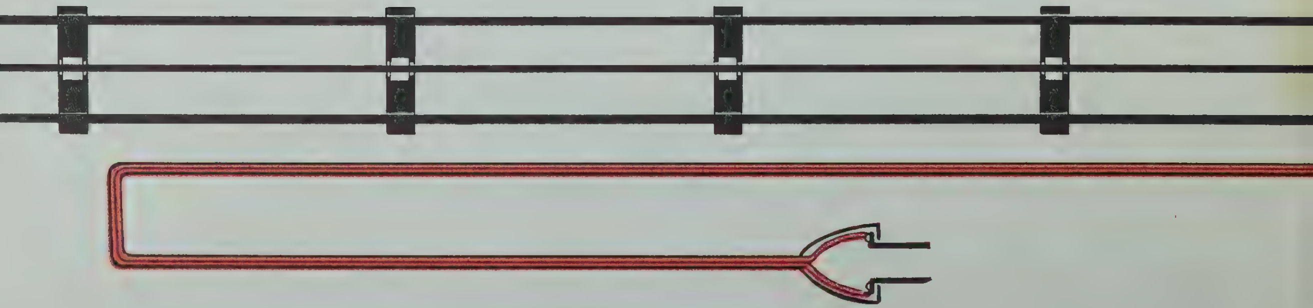
Don't you agree that electricity is as good as a magic servant?

Running Your Electric Train

Perhaps you have an electric train at home. Electric trains are among the most popular toys boys and girls play with today.

A toy electric locomotive has an electric motor in it, just as a real electric locomotive has. The diagram on these two pages shows a toy train circuit. The locomotive is drawn as if you could see through the outside. The motor inside shows.

The current of electricity comes to the motor through a third rail that is between the other two rails. A tiny wheel joined to the motor runs along on this third rail. The current flows through the wheel and the motor. Then it travels down through the big wheels of the locomotive to the two regular rails of the track. These two rails are the return wire.



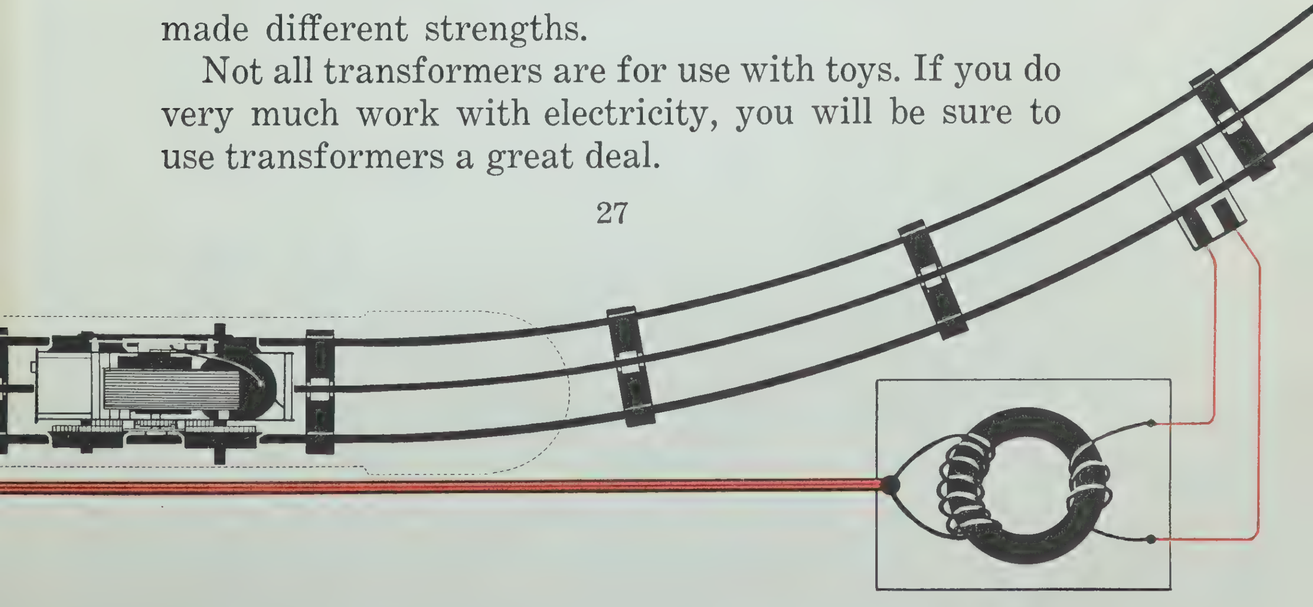
In the diagram you can see a box with a ring inside it. Wrapped around the ring there are two coils. One is joined by wires to the track. The electric cord leads to the other. The box is a small *transformer.*

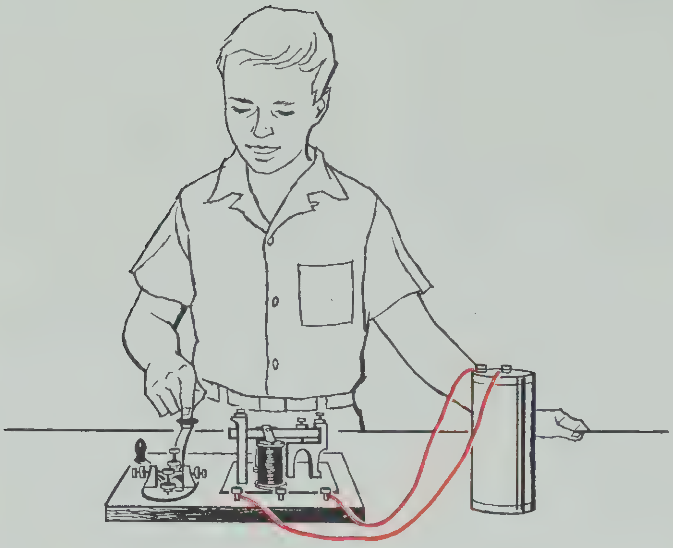
Suppose you did not use a transformer. Suppose you simply used an electric cord to join the tracks to the wall outlet. Then a strong current would flow through the train circuit. It might ruin the motor in your locomotive. At least it would make the wires in the circuit so hot that the fuse would blow out. With a transformer you can get a current that is just right for your train.

A transformer cannot be used with your house current unless the current is alternating. When an alternating current flows through one coil of the transformer, it makes a current flow through the other coil. Notice that there are more turns of wire in one coil than in the other. The number of turns of wire is important in making the current from the transformer the strength you want it to be.

Really the transformer you use with your electric train is not so simple as the one the diagram shows. There are several different coils that the wires from the tracks can be connected with. The current can be made different strengths.

Not all transformers are for use with toys. If you do very much work with electricity, you will be sure to use transformers a great deal.





A Speedy Messenger

Your father, let us suppose, has gone on a trip to a city a hundred miles away. You have to get a message to him very quickly. What will you do? You may telephone to him. You may send him a telegram. Whichever you do, you will be using electricity as a messenger.

Electricity carries messages very fast. In old Roman stories Mercury was the messenger of the gods. Mercury was speedy because he wore sandals with wings. But Mercury was slow compared with electricity. Electricity can carry messages thousands of miles in less than a second. The Romans could not even imagine so fast a messenger.

The boy in the picture on this page is practicing sending messages with a telegraph set. A set of this kind is made up of a *key* and a *sounder.* The boy is pressing the key. The sounder is on the other half of the wooden base.

The key of a telegraph set is like a push button. It makes and breaks the circuit.

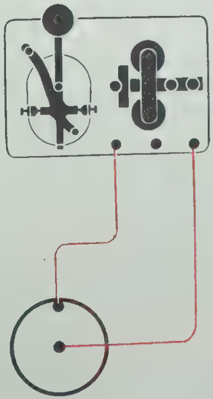
The sounder of a telegraph set has an electromagnet in it. Above the magnet is an iron bar. It is fastened to a bar of aluminum that has a screw running through it. When the key is held down, a current flows through the magnet. The magnet pulls down the iron bar. The aluminum bar comes, too. The screw hits a piece of metal and makes a click. As soon as the key is let up, the current stops flowing. Then the magnet stops pulling the iron bar. A spring makes the iron and aluminum bars go up. The aluminum bar hits a screw above it and makes another click.

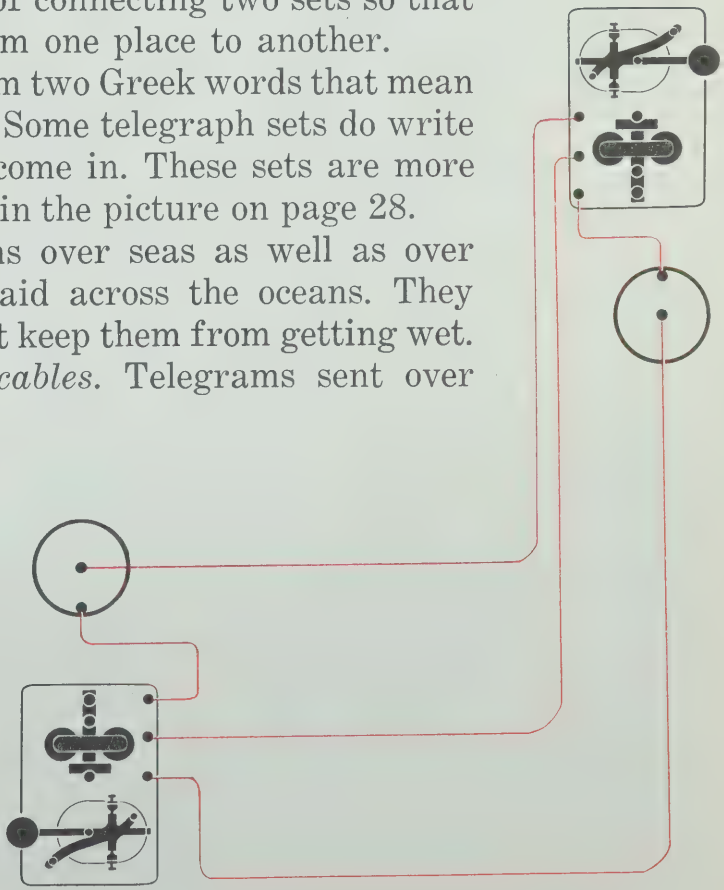
With a telegraph set like this, messages are sent in a *code* made of dots and dashes. For a dot the key is held down for a very short time. The two clicks the sounder makes come close together. For a dash the key is held down for a longer time. The clicks are farther apart. On the inside back cover you will find the code that is most often used.

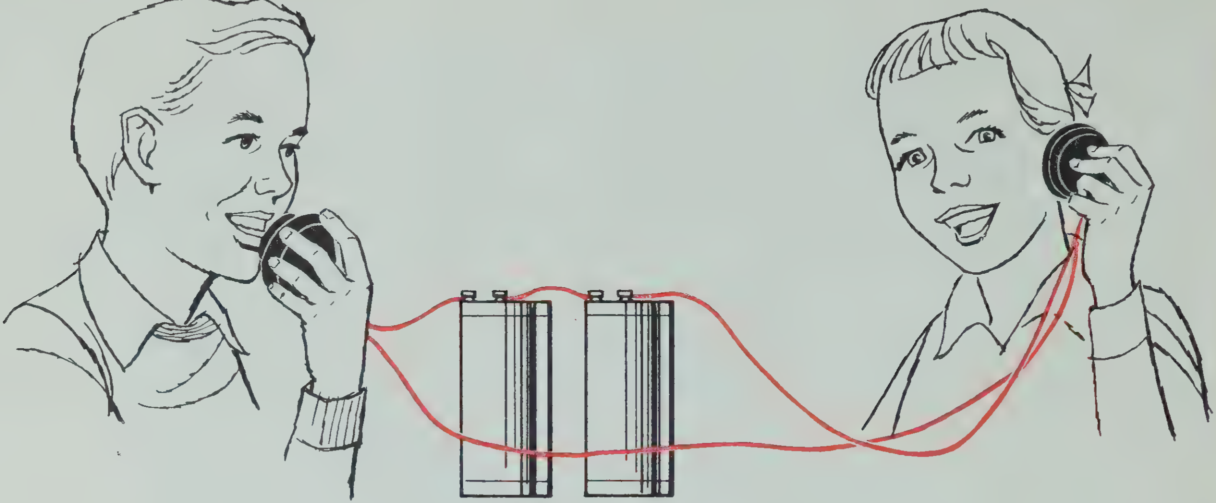
The first diagram on this page shows a practice set. The second shows a way of connecting two sets so that messages can be sent from one place to another.

"Telegraph" comes from two Greek words that mean "far away" and "write." Some telegraph sets do write down the messages that come in. These sets are more complicated than the one in the picture on page 28.

We can send telegrams over seas as well as over land. Wires have been laid across the oceans. They have thick wrappings that keep them from getting wet. These wires are called *cables.* Telegrams sent over them are *cablegrams.*





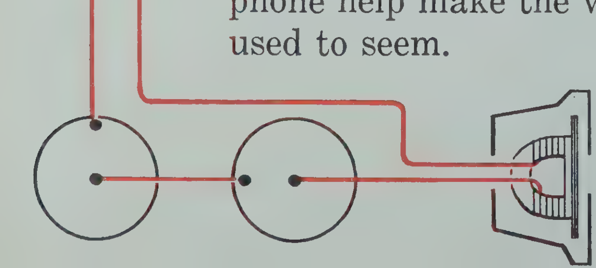


The boy in the picture on this page is talking to the girl over a simple telephone line. He is talking into a *transmitter*. She is holding a *receiver* to her ear. The circuit is very simple. Real telephone lines are much more complicated.

The most important parts of a transmitter are a thin sheet of metal and a little box filled with bits of carbon. The most important parts of a telephone receiver are an electric magnet and a thin sheet of iron. These parts show clearly in the diagram at the bottom of the page.

When you talk to a friend on the telephone, you may think that you hear his voice. You really do not. No sound travels over the wires between your telephone and his. Only a current of electricity goes through these wires. What you hear does sound very much like your friend's voice, but it is made right in your telephone receiver. The current of electricity makes the receiver repeat what is said into the transmitter.

Now you can talk over the telephone to a person a thousand or more miles away, just as you can to your friend in the next block. The telegraph and the telephone help make the world seem much smaller than it used to seem.



Radio

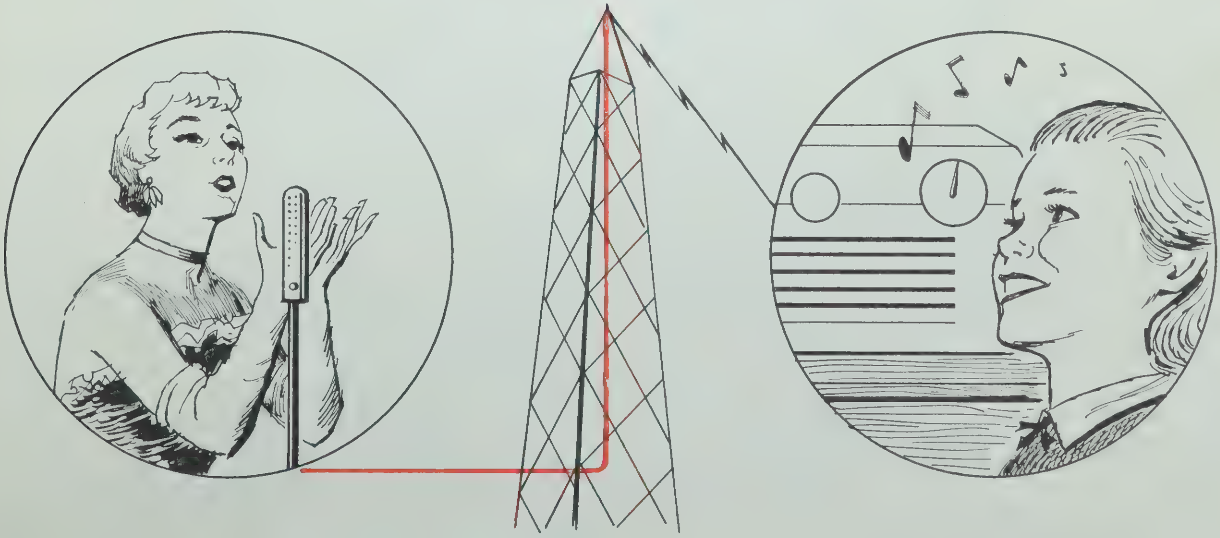
Radio does even more to bring the world right into our homes. When we turn on our radio sets we may get a program from halfway around the world.

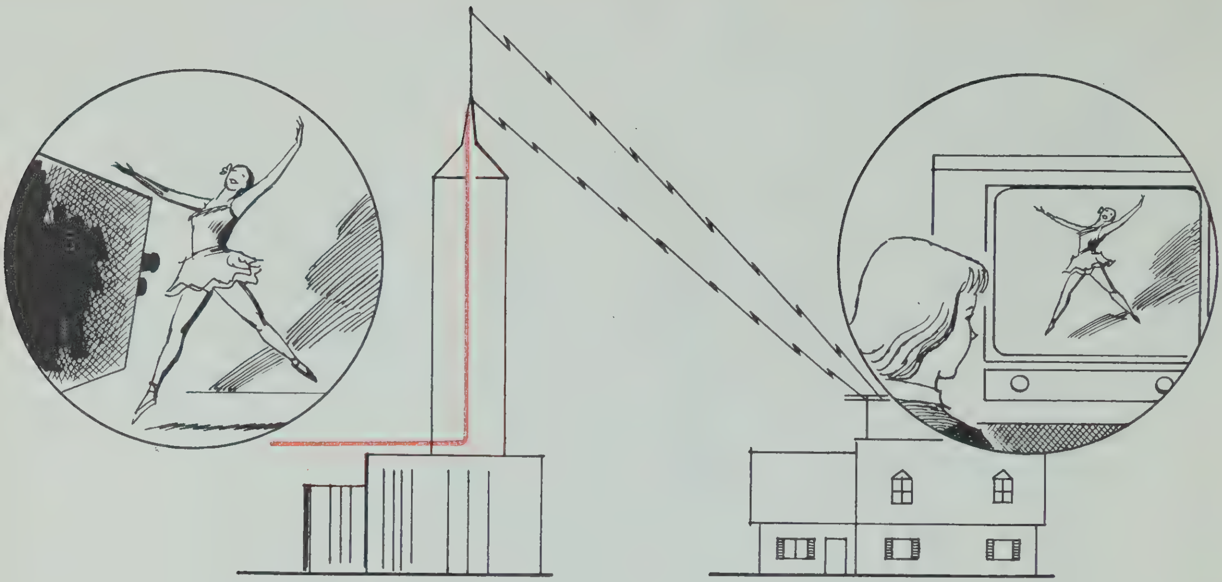
The sounds coming from a radio set are made in the set itself. The loud speaker repeats the sounds made into the microphone at the broadcasting station. A loud speaker, you see, is like a telephone receiver.

There is one big difference, however, between the telephone and radio. Currents of electricity bring us messages by telephone. Radio programs and messages travel by radio waves. Radio waves go through the air, not through wires. At broadcasting stations the radio waves are sent out from tall towers. A receiving set must have an aerial to catch the waves. Today in most radio sets the aerials are built in.

No current travels from the broadcasting station to our radio sets, but a current of electricity does start the waves on their way. And our receiving sets have a current flowing through them.

Radio sets are complicated. Vacuum tubes play an important part in most of them. In some sets tiny transistors are used instead. The story of how all the parts work is much too long to be told here.





Television

Television sets are even more complicated than radio sets. With them we can both see and hear from far away. At a broadcasting station there is a television camera as well as a microphone. Not only sounds but pictures, too, are carried from the broadcasting station by means of radio waves. The pictures on the screen of the camera at the broadcasting station are made again on the screens of our television sets just as the sounds are repeated in the loud speakers. The part of the television set that shows us the picture is the picture tube. The screen is one end of this tube. As in radio, currents of electricity are needed for both sending and receiving.

A television set must have an aerial for the waves to strike. Television aerials on the tops of buildings are now a common sight. There are inside aerials of various shapes and sizes, too.

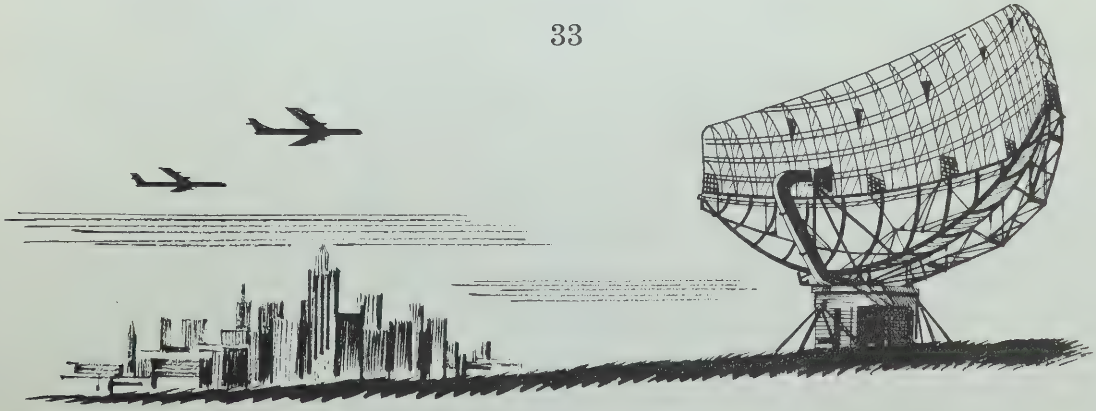
Radio can reach a person anywhere in the world if he has a good enough receiving set. But television cannot. The waves used for most radio broadcasting are reflected by a layer of air high above the earth. They can reach people far away. The waves from television stations are not bent. They travel straight out into space. One cannot count on getting good pictures on television unless there is a broadcasting station within 100 miles.

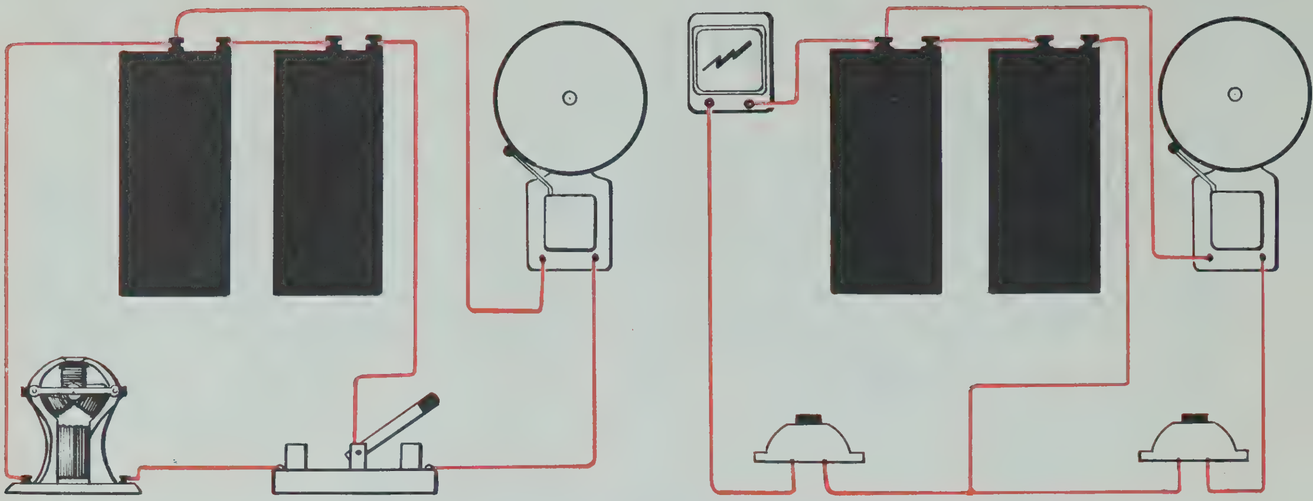
Radar

Radar is another way of using radio waves. Very short radio waves are sent out from a radar station. They do not go in all directions as they do in radio and television broadcasting. Instead, they are sent out in a beam. If they strike something they cannot go through, they bounce back just as sound waves do in an echo. They reach the aerial from which they were sent out. On a screen much like a television screen they then make a very simple picture of what they hit.

Radar operators know that radio waves travel as fast as light. They can tell from the length of time it takes the waves to bounce back how far away what shows on the screen is.

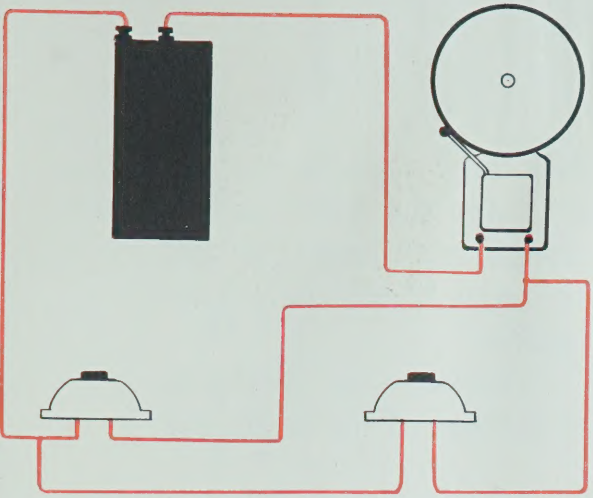
Radar proved to be a big help in World War II. With it enemy planes coming near could be spotted. Today many nations have radar stations on their borders. But radar is not just for wartime. It helps pilots find their way in darkness and fog. It helps seamen bring their ships safely into port. It helps the weatherman study the weather.

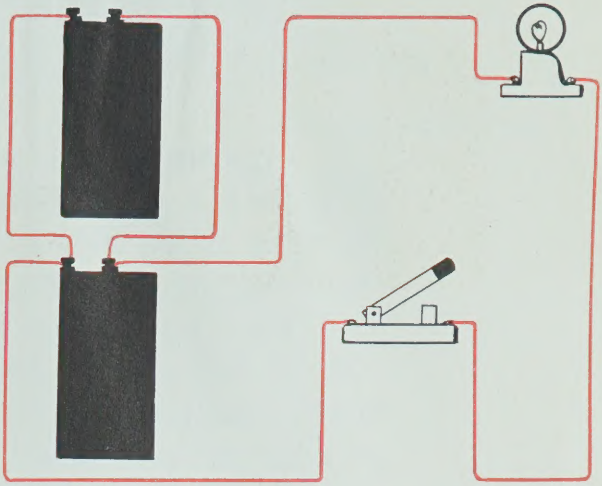




Do You Know Now?

1. Lightning is a huge spark of electricity.
2. We can get charges of electricity with friction.
3. There are two kinds of electric charges.
4. Charges that are alike repel each other. Those that are not alike attract each other.
5. We get electric currents from cells or generators.
6. We use electricity to make bells ring.
7. We use electricity to give us light and heat.
8. Electricity does a great deal of work for us.
9. Electric magnets are very useful.
10. Electricity is a fast messenger.
11. Some materials are very good conductors of electricity; some are very poor conductors.
12. A path for a current of electricity is called a circuit.
13. If there is a gap in the path for the current, we say that the circuit is broken.
14. If the current is flowing along the path we wish it to follow, we say that the circuit is complete.
15. If the current takes an easier path, we say that there is a short circuit.
16. Switches and push buttons are for making and breaking circuits.





See for Yourself

1. Try the experiments shown on pages 4, 6, and 7.
2. Cut a tiny airplane out of aluminum foil and do what the boy in the picture on page 5 is doing.
3. Take a dry cell apart. Find the parts shown in the middle diagram on page 9.
4. If some grown person can help you, make a wet cell like the one in the first diagram on page 9.
5. Make an electric bell ring in the three ways the pictures on page 10 show.
6. Set up the second circuit shown on page 11.
7. Connect a little electric lamp with a switch and two dry cells. The left-hand diagram on page 15 will help you.
8. Take a flashlight apart. Find the parts shown in the right-hand diagram on page 15.
9. Make a small electromagnet by wrapping several feet of insulated wire around an iron bolt. Use the magnet to move a pile of iron filings (small bits of iron) from one place to another.
10. Get pieces of at least ten different materials. Set up the first circuit on page 12. By touching the free ends of the wires to one material after another, find out which of these materials are good conductors.

11. [illegible] button. Show how a short circuit may make the bell ring all the time. Show how a short circuit may keep the bell from ringing. The diagrams on page 12 will help you.

12. Visit an electric power plant.

13. If you have a string of Christmas tree lights at home, examine it. Which of the strings of lights shown on page 22 is it like?

14. Connect an electric plate or an electric heater. Watch the wires get red.

15. Make a toy electric motor run. Make the motor run some other toy.

16. Practice sending a message with a telegraph set. Connect the set the way the first diagram on page 29 shows. Move the switch out if it is closed.

17. Connect two telegraph sets. Send messages.

18. Connect a telephone transmitter and receiver with two dry cells. Talk over the line.

19. Set up the circuit the first diagram on page 34 shows. The switch is a *double-throw switch*. The bell will ring if you push the arm of the switch down in one direction. The motor will run if you push the arm of the switch down in the other direction.

20. Set up the circuit the second diagram on page 34 shows. The bell will ring if you push one push button. The buzzer will buzz if you push the other push button.

21. Set up the circuit the first diagram on page 35 shows. The bell will ring when you push either button.

22. You have found out that electric lights are often connected in parallel. Cells may be connected in parallel, too. The second diagram on page 35 shows how. Set up the circuit. The two cells will not make the light any brighter than one cell makes it. But they will last much longer than one cell.

Litho. in U.S.A.

Q 181 P233 1961 BK-25
PARKER BERTHA MORRIS
BASIC SCIENCE EDUCATION
SERIES
NL 40042831 CURR HIST
000032319881

A ● ▬
B ▬ ● ● ●
C ▬ ● ▬ ●
D ▬ ● ●
E ●
F ● ● ▬ ●
G ▬ ▬ ●
H ● ● ● ●
I ● ●
J ● ▬ ▬ ▬
K ▬ ● ▬
L ● ▬ ● ●
M ▬ ▬
N ▬ ●
O ▬ ▬ ▬
P ● ▬ ▬ ●
Q ▬ ▬ ● ▬
R ● ▬ ●
S ● ● ●
T ▬

X ▬ ● ● ▬
Y ▬ ● ▬ ▬
Z ▬ ▬ ● ●
. ● ● ● ● ● ●
, ● ▬ ● ▬ ● ▬
? ● ● ▬ ▬ ● ●

1 ● ▬ ▬ ▬ ▬
2 ● ● ▬ ▬ ▬
3 ● ● ● ▬ ▬
4 ● ● ● ● ▬
5 ● ● ● ● ●
6 ▬ ● ● ● ●
7 ▬ ▬ ● ● ●
8 ▬ ▬ ▬ ● ●
9 ▬ ▬ ▬ ▬ ●
0 ▬ ▬ ▬ ▬ ▬